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Choosing and Sharing

Jérémy LAURENT-LUCCHETTI
Justin LEROUX

Cahier de recherche n° IEA-07-13

3000, chemin de la Côte-Sainte-Catherine
Montréal (Québec) Canada H3T 2A7
www.hec.ca/iea

Choosing and Sharing

Jérémy Laurent-Lucchetti and Justin Leroux[*†]

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Abstract

Choosing a project for which benefits accrue to all involved agents but brings major costs or additional benefits to only one agent is often problematic. Siting a nationwide nuclear waste disposal or hosting a major sporting event are examples of such a problem: costs or benefits are tied to the identity of the host of the project. Our goals are twofold: to choose the efficient site (the host with the lowest cost or the highest localized surplus) and to share the cost, or surplus, in a predetermined way so as to achieve redistributive goals. We propose a simple mechanism to implement both objectives. The unique subgame-perfect Nash equilibrium of our mechanism coincides with truthtelling, is efficient, budget-balanced and immune to coalitional deviations.

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[*] HEC Montréal, Institut d'Économie Appliquée and CIRPÉE.

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1 Introduction

The search for hazardous waste landfills and nuclear waste repositories in the United States and in many other countries has proven to be a difficult task. Even when offered monetary compensation, very few communities have accepted to host such facilities. Since the mid-70's only one small radioactive waste disposal facility and a single hazardous waste landfill (fittingly located in Last Chance, Colorado) have been sited in the United States (see Gerrard, 1994). Consequently, the U.S. nuclear industry still faces a major problem. Several other similar programs face social rejection from local populations: noxious facilities, prisons, airports, etc. These public goods are socially necessary but come with local externalities (noise, pollution, noxious odors, etc) or bear a negative connotation. Different factors can generate such rejection: the loss in the economic value of property, loss in the perceived quality of life or the fear of health hazards. In economic terms, these public goods have a private-bad aspect which creates a siting problem (the so-called "NIMBY" problem, for "Not In My Backyard"): all communities will benefit from the good, but only one (the host) will bear the cost.

Choosing a host for a project which generates desirable local externalities, such as a major international research project (like the International Thermonuclear Experimental Reactor, ITER) or a major sporting event (the Olympic Games), is not an easier task to accomplish. Here, benefits accrue to all (as in the "local bad" case) but the host obtains an additional localized surplus. Consequently, all communities compete to be the host. The selection is then a long and tedious process where each participant tries to prove that it is the best candidate. For more readability, we consider the case of a project which generates negative externalities throughout the body of the paper. However, a locally desirable project generating positive externalities could easily be formalized in this framework (see appendix).

Conventional siting approaches of a "local bad" are currently characterized by a decide-announce-defend structure (see Easterling, 1992, Minehart and Neeman, 2002, the Environmental Protection Agency, 2002, and Marchetti, 2005, for comprehensive reviews). First, (secret) investigations are carried out to evaluate the technical suitability of a location. Then, the prospective host community is confronted with the siting proposal and promises of compensation. Alternatively, the economic approach reverses the procedure: each community involved in the project has to reveal the cost it would incur should it be the host, the host is then chosen. Note that this cost could be the composite of a technical cost (e.g. the physical construction cost, specific to the community) and a disutility (e.g. the aggregation of the preferences of the inhabitants over the externalities of the project).

The first aspect of the problem is the choice of a host. The overall cost of the project is tied to the identity of the host. Thus, efficiency asks that the host be the community which incurs the lowest disutility. Then, this cost should be shared between communities to insure the necessary agreement of all involved agents, which is the second aspect of the problem. It may happen that even when the efficient host is identified, there still could exist strong opposition (from the host or other participants) preventing the efficient outcome from occurring: we thus face a redistribution issue. As pointed out in Easterling (1992) and Frey et al. (1996), the structure of the compensation itself could result in the rejection of the project. Numerous papers in fields other than economics also emphasize this point (see, for a social-psychological approach, Pol et al., 2006, or Kuhn and Ballard, 1998, for a geographic viewpoint): redistribution is intrinsically part of the selection problem.

For example, the long and difficult process of selecting a location for the international project ITER was solved by an agreement on the redistribution scheme (France, Japan, Canada and Spain both proposed to host the project): "the decision to site ITER at Cadarache [France] was finally taken on June 28 [2005]. A compromise formula between Europe and Japan over cost-sharing, in particular the respective contributions of industrial hardware and personnel to the project, made this possible."[1].

In fact, the planner may wish to select a specific sharing outcome while choosing a site, which could take into account the voluntary participation of involved communities (no community should pay more than the benefits it derives from the project), their budget constraints, their respective involvement in the project or any other rel-

[1] India's National Magazine, 14/01/2006. Participating members of the ITER cooperation agreed on the following division of funding contributions: the six non-host partners will contribute 6/11th of the total cost while the host (European Union) will put in the rest. As for the industrial contribution, five countries (China, India, Korea, Russia, and the US) will contribute 1/11th each, Japan 2/11th, and EU 4/11th.

evant characteristic. Taking into account redistribution issues could ease the siting process.

We propose a simple mechanism for choosing the host of a project which implements any reasonable redistribution scheme. The informational context we use is one where the communities know each other's characteristics (benefits and costs), but the planner does not. This assumption, while restrictive, reasonably approximates environments where the agents involved in the project have much more information than the planner (e.g. communities in a region are better informed about their mutual characteristics than the federal state). We show that the unique subgame-perfect Nash equilibrium of our mechanism coincides with truth-telling (the host reveals its true disutility). Moreover, the host chosen in equilibrium is the efficient one (whenever carrying out the project turns out to be efficient) and the outcome is budget-balanced.

Additionally, our approach incorporates a component which, to the best of our knowledge, has not been considered in the literature: the benefits that communities obtain if the project is carried out. We believe that adding this benefit component enhances the model in at least two ways. First, it determines explicitly whether the project should be carried out (if the sum of the benefits exceeds the total cost). Additionally, it allows the planner to place an upper bound on the cost share that each community will be asked to pay (so as to ensure voluntary participation), if stability is considered to be an issue. In fact, our mechanism enforces voluntary participation by allowing a net loser to opt out of the procedure.

The mechanism we propose proceeds in two stages: in the first stage, each community announces the lowest cost which would be incurred if the project were sited in a community other than itself (the community announcing the lowest cost will be referred to as the "optimist") and, in the second stage, each community announces its own cost of hosting the project. The host is selected among those communities which announce the lowest cost in the second stage. Compensation transfers are then implemented. The key point is that each community pays a cost share which is independent of its own announcement: the optimist's share depends on the announcement of the host, while the host and the other communities pay according to the optimist's announcement. The host is compensated by the amount announced by the optimist and balanced the budget if its announcement is different than the optimist's one. Thus, it is a weakly dominant strategy for all communities to announce the true cost of the efficient community on the first stage (except for the host), and its own true cost on the second stage. At the unique subgame perfect Nash equilibrium the host is the community with the lowest cost and the total cost to be shared is the actual one. This unique equilibrium is immune to coalitional deviations.

The rest of the paper is organized as follows. In Section 2 we review more precisely the economic literature on the siting issue. Section 3 exposes the model, while Section 4 presents the mechanism and the theorems. In Section 5 we discuss three issues related to our mechanism: we present a procedure for revealing the profile of benefits *and* the profile of costs (a composite of our mechanism and the one of Jackson and Moulin, 1992), we discuss the case where the profiles of benefits and costs condition cost-shares of communities and we present the two agents case.

2 Related Literature

Several methods are known for selecting an outcome out of a set of alternatives. The trade-off between efficiency, budget balance and incentive-compatibility is central in all these methods. One class of mechanisms selecting efficiently is that of Vickrey-Clark-Groves (VCG) mechanisms. Announcing one's real disutility is a dominant strategy (thus the efficient outcome is chosen) but the mechanism fails to balance the budget: it generates a surplus which cannot be redistributed between the agents in order to preserve the strategic properties of the method (see Moulin, 2007, Section 4, for a VCG treatment of the NIMBY problem).

To the best of our knowledge, Kunreuther and Kleindorfer (1986) are the first to explicitly consider the siting of a public good generating a local nuisance. They propose a sealed-bid auction where the host community receives its own bid as compensation and other communities pay their bid divided by the number of communities minus one. They show that the outcome is efficient (but not budget-balanced) if communities employ maximin strategies.

O'Sullivan (1993) investigates Bayesian-Nash equilibrium behavior under a sealed-bid auction where the city submitting the lowest bid hosts the project and receives the highest bid as compensation (thus failing to balance the budget). In the same vein, Minehart and Neeman (2002) propose a method adapted from a second-price auction to site a project. The project is sited in the community with the lowest cost or, if not (compensation induces misrepresentation of costs), the authors argue that the efficiency loss is small. The procedure is self-financed but the host obtains a surplus because it is compensated with the second lowest bid, as in a second price auction.

The fact that redistribution is an issue when selecting a host for a project is pointed by numerous studies, often from a normative viewpoint. Marchetti and Serra (2004) consider the siting problem as a cooperative game. They study the standard solutions of cooperative game theory (the Shapley value, the nucleolus and the core) with an asymmetry in the value function: the value of the cooperation changes when the host changes. Additionally, they design an experiment and test which solution is the most appealing for participants. Also, Sakaï (2006) axiomatizes the properties of the proportional procedure used by Minehart and Neeman (2002).

In a companion paper, Laurent-Lucchetti and Leroux (2007) define desirable properties which a cost-sharing method should meet, and characterize the Equal Responsibility Method. This method shares the cost in proportion of the benefits each community obtains from the project. It meets the important Voluntary Participation property (no community should pay more than the benefits it obtains from the project) and two other properties: one aiming to remove the natural asymmetry of the problem and another which imposes solidarity when population movements occur between communities (a point raised by Sullivan, 1990, and Baumol and Oates, 1998).

Regarding implementation, no selection mechanism allows to freely choose the redistribution scheme once the host has been selected, to the best of our knowledge. The mechanism we propose here allows for the implementation of any reasonable redistribution scheme and shares several features of that developed in Jackson and Moulin (1992), which explicitly treats this redistribution issue while constructing a public good. However, the problem they consider is quite different: it is not a selection problem as they consider only one possible project. The cost of construction is known and agents' characteristics are the benefits each community obtains if the public project is built. At every undominated Nash equilibrium of their mechanism, the public project is undertaken when the sum of benefits outweighs its cost. A large range of cost-sharing methods can be implemented by the planner.

Closer to our concern, Perez-Castrillo and Wettstein (2002) develop a *multi-*

bidding mechanism to solve the selection problem: each community submits a vector of bids (one bid by potential site), where each bid is interpreted as the amount it is willing to pay if the project is sited in this specific community. The sum of bids submitted by any one community must sum up to zero. In addition each agent announces a project (interpreted as its "preferred" site). The project with the highest aggregate bid is chosen as the winner and each community pays its bid for this site. In case of a tie, the winning project is randomly chosen among those with highest aggregate bid which are announced by at least one agent[2]. They show that a Nash equilibrium always exists and that in any Nash equilibrium an efficient project is carried out. Their procedure is budget-balanced at every Nash equilibrium. They also show that every Nash equilibrium of the game is a strong Nash equilibrium (immune to coalitional deviation). The main drawback of their approach is that the planner cannot select a specific redistributive outcome, they only guarantee that at each Nash equilibrium a community obtains at least its *expected* payoff (the payoff if the site is randomly chosen). Therefore, the planner cannot induce the outcome to take into account voluntary participation, budget constraint or any other relevant characteristic of the participating agents. Our mechanism improves upon theirs as it admits a unique (subgame perfect) Nash equilibrium and, additionally, allows the planner to implement any reasonable redistribution scheme. This equilibrium is also immune to coalitional deviations.

3 The Model

Let $N = \{1, ..., n\}$ be the set of communities. Each community $i = 1, ...n$ obtains a benefit, b_i, if the project is carried out and endures a disutility, d_i, if it is chosen to host the project[3]. We take the view that d_i encompasses the actual construction cost of the project plus the disutility of the communities, both of which are community-

[2]Ehlers (2007) considers a "natural multi-bidding mechanism" where an agent does not announce it's preferred project. Here, the planner asks agents to submit bids only and interprets an agent's announced projects to be the ones with the maximal bid. He shows that this interpretation puts severe restrictions on the existence of NE in the natural multi-bidding mechanism. In particular when one project is unambiguously efficient, then no equilibrium exists.

[3]In the body of the paper, we shall assume $d_i \geq 0$ (the case of a "local bad"). The case $d_i \leq 0$ (for a "local good") is similar and will be detailed in the appendix.

specific. Let $b = (b_i)_{i\epsilon N}$ be the profile of benefits and $d = (d_i)_{i\epsilon N}$ be the disutility profile. The profile of benefits is taken to be common knowledge (see Section 5 for a procedure to reveal this profile as well). The profile of disutilities is known by all communities, but not by the planner. Thus, the total payoff of a community i if the project is carried out is given by u_i:

$$u_i = b_i - \mathbb{I}(i = host)d_i - t_i \tag{1}$$

where t_i is the transfers paid by community i and $\mathbb{I}(i = host)$ is the indicator function equal to 1 if i is the host and 0 otherwise. A project is *efficient* if its host h is such that $d_h = min(d_i)$ and if the sum of benefits outweighs this cost:$\sum_N b_i \geq d_h$. Without loss of generality we rank communities from lowest to highest disutilities: $d_1 \leq d_2 \leq .... \leq d_n$. Thus, a project is efficient if $d_h = d_1$ and $\sum_N b_i \geq d_1$.

We design a mechanism which selects a host community and assigns nonnegative cost-shares $\alpha_i(\theta)d_h$ to each community i, where θ is a set of exogenous (and known) characteristics relevant for sharing the cost (revenue of a community, etc), and where $\sum_N \alpha_i(\theta) = 1$. In Section 5, we will discuss the case where b_i and d_i are included in θ.

4 The Mechanism

The mechanism has two stages, we will focus on its subgame perfect Nash equilibrium.

Stage 1: Each community i announces the lowest disutility that would be paid if the good is sited in an other community that itself: $d^i = min(d^i_j)$ for all $i \neq j$. Define $\underline{d}$ as the $min(d^i)$. The community i which announce $\underline{d}$ will be referred to as the community i^* (the "optimist"). If there is more than one "optimist" then any tie-breaking rule could be applied to select one i^*. If $\sum_N b_i \geq \underline{d}$ we proceed to stage 2, otherwise we stop and the project is not carried out.

Stage 2: Given $\underline{d}$ and i^*, each community other than i^* announces its own disutility: δ_i. Define δ_h as the $min_{i \neq i^*}(\delta_i)$. The host community ("$h$") will be (randomly) selected among those announcing δ_h.

Then, the following transfers are implemented:

$$\begin{cases} t_{i^*} = \alpha_{i^*}(\theta)\delta_h \\ t_i = \alpha_i(\theta)\underline{d} \\ t_h = -\underline{d} + \alpha_h(\theta)\underline{d} + |\underline{d} - \delta_h| \end{cases}$$

If $\delta_h \geq \sum_N b_i$, the host is randomly chosen from the set of δ_i for all $i \neq i^*$. In that case, the transfers differ from the above expression only in that $t_h = -\underline{d} + \alpha_h(\theta)\underline{d}$ (i.e. agent h no longer pays the difference between $\underline{d}$ and δ_h).

Once the transfers are known, the planner gives the opportunity to each community i such that $t_i > b_i$ to opt out of the mechanism. If no community opts out, the procedure ends. Otherwise, we repeat the procedure excluding the communities which have opted out.

Thus, if the project is carried out, the payoff of each community is:

$$\begin{cases} u_{i^*} = b_{i^*} - \alpha_{i^*}(\theta)\delta_h \\ u_i = b_i - \alpha_i(\theta)\underline{d} \\ u_h = b_h - \alpha_h(\theta)\underline{d} + (\underline{d} - d_h) - |\underline{d} - \delta_h| \end{cases}$$

Theorem 1. *Let $n \geq 3$, the unique subgame perfect Nash equilibrium of the mechanism coincides with truthful revelation, $\delta_h = \underline{d} = d_1$, whenever it is efficient to carry out the project. Otherwise the project is not carried out. The outcome is efficient, budget-balanced and achieved without any community opting out as long as $t_j(\theta) \leq b_j$ for all j.*

Proof. Step 1: $\delta_h = \underline{d}$

- Suppose a subgame perfect Nash equilibrium (SPNE) existed where $\delta_h > \underline{d}$. If $\underline{d} > d_h$, then, h could obtain a higher payoff by announcing a lower δ_h. If $\underline{d} < d_h$, then, h could obtain a higher payoff by announcing $\hat{\delta_h} > \delta_{h2}$, where δ_{h2} is the second lowest δ. Then, h is no longer the host, it "becomes" an agent i and obtains a higher payoff. Thus, $\delta_h > \underline{d}$ cannot be part of a SPNE of the mechanism.

- Suppose a SPNE existed where $\delta_h < \underline{d}$. Then, h could obtain a higher payoff by announcing a higher δ_h. Thus, $\delta_h < \underline{d}$ cannot be part of a SPNE of the mechanism.

Step 2: $\delta_h = \underline{d} = d_h$

- Suppose a SPNE existed where $\delta_h = \underline{d} > d_h$. Then, in first stage, i^* could obtain a lower cost share by announcing a lower $\underline{d}$ (and, by step 1, its cost δ_h). Thus, $\delta_h = \underline{d} > d_h$ cannot be part of a SPNE of the mechanism.

- Suppose a SPNE existed where $\delta_h = \underline{d} < d_h$. Then, in the second stage, h could obtain a higher payoff by announcing $\hat{\delta_h} > \delta_{h2}$ (step 1). Thus, $\delta_h = \underline{d} < d_h$ cannot be part of a SPNE of the mechanism.

Step 3: $d_h = d_1$

- Suppose a SPNE existed where $\delta_h = \underline{d} = d_h > d_1$. Then, 1 could obtain a higher payoff by announcing $\delta_1 < \delta_h$ and becoming the host. Thus, $\delta_h = \underline{d} = d_h > d_1$ cannot be part of a SPNE of the mechanism. Hence, because $d_h \geq d_1$ (with our notation), it must be that $d_h = d_1$.

We leave it up to the reader to check that the strategy profile below supports this SPNE:

Each agent i plays the following strategy:

Stage 1:

- Announce $d^i = min_{j \neq i}(d_j)$.

Stage 2:

- If $\underline{d} < d_1$: Announce $\delta_i = \sum_N b_i + \epsilon$.

- if $d_2 \geq \underline{d} \geq d_1$: Announce $\delta_i = d_i$.

- If $\underline{d} \geq d_2$: Announce $\delta_i = d_i$ if $d_i \geq \underline{d}$, or $\delta_i = 0$ if $d_i < \underline{d}$.

□

Hence, if a subgame-perfect Nash equilibrium exists, it is unique and it coincides with the truth-telling outcome: whenever it is efficient to build, the host is an efficient one, and the cost to be shared is the true cost. One important concern regarding the selection of an efficient outcome in Nash equilibrium is its robustness to coalitional deviations. If a subset of agents can improve their aggregate payoff by joint deviations from the equilibrium, its stability could be compromised. It turns out that the unique subgame perfect Nash equilibrium of our mechanism is also immune to any such coalitional deviations.

Theorem 2. *For $n \geq 3$, the unique subgame perfect Nash equilibrium of the mechanism is also immune to coalitional deviations.*

Proof. For more readability, we consider only three agents which will play the role of i, i^* and h in equilibrium. The proof easily extendes to $n > 3$. We denote a variation of the variable x as Δx and we consider b, θ and α as given.

- *Step 1: Coalition of i, i^* and h*

  The unique SPNE of our mechanism is efficient: the host is one of the communities with the lowest cost, which maximizes the sum of all payoffs. Thus, this coalition (the "grand coalition") cannot increase its aggregate payoff by a joint deviation.

- *Step 2: Coalition of h and i^**

  Consider the joint payoff:

$$u_{h,i^*}(\delta_h, \underline{d}) = (b_{i^*} + b_h) - (\alpha_{i^*}(\theta)\delta_h + \alpha_h(\theta)\underline{d}) + (\underline{d} - d_h) - |\underline{d} - \delta_h|$$

  A positive variation in δ_h (given that h is still the host) decreases the joint payoff by $(1 + \alpha_{i^*}(\theta))\Delta\delta_h > 0$. If $\delta_h + \Delta\delta_h > \delta_{h2}$, roles change ($h$ "becomes" an agent i), then the joint payoff decreases by $\alpha_{i^*}(\theta)(\delta_{h_2} - \delta_h) \geq 0$. A negative variation in δ_h decreases the joint payoff by $(1 - \alpha_{i^*}(\theta))|\Delta\delta_h| \geq 0$.

A negative variation in $\underline{d}$ decreases the joint payoff by $(2 - \alpha_h(\theta))|\Delta \underline{d}| > 0$. A positive variation in $\underline{d}$ is impossible given the equilibrium strategy profile: community i announces $d^i = d_1$ in first stage and $\underline{d}$ is chosen as the minimum value of that set.

Coordinated deviations from $\underline{d}$ and δ_h (given the equilibrium strategy profile, $\Delta \underline{d}$ could not be positive): if the variations are in opposite directions (positive for δ_h and negative for $\underline{\mathrm{d}}$) the joint payoff decreases by the sum of the corresponding impact previously described. If the variations are both negative the joint payoff decreases by $|\Delta \underline{d}| + |\Delta \underline{d} - \Delta\delta_h| - (\alpha_{i^*}(\theta)|\Delta\delta_h| + \alpha_h(\theta)|\Delta \underline{d}|) \geq 0$.

Thus, $u_{h,i^*}(\delta_h, \underline{d}) \geq u_{h,i^*}(\delta_h + \Delta\delta_h, \underline{d} + \Delta \underline{d})$.

- *Step 3: Coalition of h and i*

  Consider the joint payoff:

$$u_{h,i}(\delta_h, \underline{d}) = (b_i + b_h) - (\alpha_i(\theta)\underline{d} + \alpha_h(\theta)\underline{d}) + (\underline{d} - d_h) - |\underline{d} - \delta_h|$$

  A positive variation in δ_h (given that h is still the host) decreases the joint payoff by $\Delta\delta_h > 0$. If $\delta_h + \Delta\delta_h > \delta_{h2}$, roles changes ($h$ "becomes" an agent i) and the joint payoff does not change. A negative variation in δ_h decreases the joint payoff by $|\Delta\delta_h| > 0$.

  A negative variation in $\underline{d}$ decreases the payoff by $(2 - \alpha_{i^*}(\theta))|\Delta \underline{d}| > 0$ (i "becomes" i^* given the profile of strategies which sustains the equilibrium). A positive variation is impossible given the equilibrium strategy profile: community i^* announces $d^{i^*} = d_1$ in first stage and, by definition, $\underline{d}$ is randomly chosen among the minimum values of that set.

  Coordinated deviations from $\underline{d}$ and δ_h (given the equilibrium strategy profile, $\Delta \underline{d}$ could not be positive): if the variations are in opposite directions (positive for δ_h and negative for $\underline{\mathrm{d}}$) the joint payoff decreases by the sum of the corresponding impact previously described. If the variations are both negative (i "becomes" i^* given the profile of strategies which sustains the equilibrium) the payoff decreases by $|\Delta \underline{d}| + |\Delta \underline{d} - \Delta\delta_h| - (\alpha_{i^*}(\theta)|\Delta\delta_h| + \alpha_h(\theta)|\Delta \underline{d}|) \geq 0$.

  Thus, $u_{h,i}(\delta_h, \underline{d}) \geq u_{h,i}(\delta_h + \Delta\delta_h, \underline{d} + \Delta \underline{d})$.

- *Step 4: Coalition of i and i^**

  Consider the aggregate payoff:

  $$u_{i,i^*}(\delta_h, \underline{d}) = (b_{i^*} + b_h) - (\alpha_{i^*}(\theta)\delta_h + \alpha_i(\theta)\underline{d})$$

  Given the strategy profile which sustains the equilibrium, a negative variation in $\underline{d}$ decreases the joint payoff by $(\sum_N b_i + \epsilon) - d_1 \geq 0$ if i follows its equilibrium strategy and h is randomly chosen as the host, by $((\sum_N b_i + \epsilon) - d_1) + (d_i - \underline{d}) + |\underline{d} - \delta_h| > 0$ if i follows its equilibrium strategy and i is randomly chosen as the host, or by $(d_i - \underline{d}) + |\underline{d} - \delta_i| > 0$ if i becomes the host without following its equilibrium strategy. A positive variation in $\underline{d}$ decreases the joint payoff by $\alpha_{i^*}(\theta)\Delta\underline{d} \geq 0$.

  A negative variation of δ_i such that $\delta_i + \Delta\delta_i < \delta_h$ implies that agent i becomes the host and the joint payoff decreases by $(d_i - \underline{d}) + (1 - \alpha_{i^*}(\theta))|\Delta\delta_h| > 0$ ($\underline{d} \leq d_i$ given the equilibrium strategy profile).

  Coordinated deviations from $\underline{d}$ and δ_i such that $\delta_i + \Delta\delta_i < \delta_h$: the variations cannot be in opposite directions because, given the equilibrium strategy profile, agent i cannot increases δ_h and if it announces $\delta_i + \Delta\delta_i < \delta_h$ it becomes the host (and h becomes i) so $\underline{d}$ cannot increase anymore. If the variations are both negative (i "becomes" h given the profile of strategies which sustains the equilibrium) the joint payoff decreases by $|\Delta\underline{d}| + |\Delta\underline{d} - \Delta\delta_i| - (\alpha_{i^*}(\theta)|\Delta\delta_h| + \alpha_i(\theta)|\Delta\underline{d}|) \geq 0$.

  Thus, $u_{i,i^*}(\delta_h, \underline{d}) \geq u_{i,i^*}(\delta_h + \Delta\delta_h, \underline{d} + \Delta\underline{d})$

$\square$

5 Discussion

If the profile b is unknown and the planner wishes to include it in the variables conditioning cost shares, then a combination of our mechanism and the one of Jackson and Moulin (1992, referred to as J&M from now on) could be used to obtain it. We consider, as in J&M, that a cost-sharing method is a mapping α associating to every profile b a vector of non-negative cost shares $\alpha_i(\theta, b)$. Monotonicity properties are required (see J&M, Section 3, for more details): first, $\alpha_i(\theta, b)$ as to be non-decreasing in b_i and non-increasing in b_{-i}. Additionally, when a unit of agent i's benefit is shifted to agent j, then agent i's share could not reduce by more than the amount transferred.

The procedure we propose embeds our mechanism to the one in J&M. In the first stage of the procedure, each community announces an estimate of the *joint* benefit from the project: v_i , where $v_i \in \mathbb{R}_+$. We denote the community i announcing the highest joint benefit, v, as the agent $\hat{\imath}$. In the second stage, each community reports their own valuations for the project: β_i, where $\beta_i \in \mathbb{R}_+$. Then, we compare the sum of these valuations, β_N, to v. If $\beta_N > v$, we implement our mechanism with β_N instead of $\sum_N b_i$ and the restriction that $\hat{\imath}$ could not be the same agent as i^*. The compensation payments, t_i, take the same form as in J&M where each agent pays a cost share independent of its own valuation, and agent $\hat{\imath}$ pays the balance. If $\beta_N < v$, we implement our mechanism and different payments are made: if $\underline{d} < \beta_N$ the project is not build and no one pays anything. If $\underline{d} \geq \beta_N$, the project is not build either but transfer payments are made from $\hat{\imath}$ to the other agents so as to dissuade agent $\hat{\imath}$ to overestimate v but not high enough for agents i to underestimate β_i (see J&M for details on these transfers). If $\beta_N = v$, agent $\hat{\imath}$ choose either one of the two above outcomes.

At every undominated Nash equilibrium, this procedure selects an efficient host (whenever it is efficient to carry out the project), the highest first stage bid is equal to the joint surplus ($v = \sum_N b_i$), and the second stage bids reveal the agents' true benefits ($\beta_i = b_i$). Thus, the cost-shares $\alpha_i(\theta, b)$ are implemented. A simple modification of the above mechanism allows an implementation in subgame perfect equilibrium (as described by J&M). However it involves $(n+1)$ stages and agent $\hat{\imath}$ will be required to announce the entire profile of benefits, not just his own benefit and the joint benefit. As in J&M, we opted for presenting the shorter mechanism above for more readability.

If the planner wishes to include the profile d in α, a monotonicity property has to be introduced to maintain the strategic properties of the procedure: it must be that $\alpha_i(.)$ is non-decreasing in d_i. If the planner wishes the outcome of the mechanism to be immune to coalitional deviations, then $\alpha_i(.)$ should not depend on d_{-i}. If it is not the case, then a coalition of agents (which does not include the host community) may increases its aggregate payoff by announcing different valuations.

In a companion paper, Laurent-Lucchetti and Leroux (2007) define explicitly a property on the relation between $\alpha_i(.)$ and d. This property aims to remove the natural asymmetry of the siting problem: the cost incurred by the host, d_h, determines the total cost to be shared among the set of communities. A standard requirement, in more classical cost-sharing literature, is that if the total cost increases, no one should pay less than before; hence, in our context, if the disutility of the host is higher, no community should have a lower cost share. Thus, we extend this responsibility to all communities and require that all be subject to that cost monotonicity. We call this property *extended cost monotonicity.* It happens that this property implies (in combination with budget balance) a total insensibility of α_i to the profile d.

The two agents case: to be done...

We developed a simple mechanism for selecting a host for a project which generates local externalities (i.e. nuclear waste repository, prison, the Olympic Games...). This mechanism permits to choose the efficient site and to implement multiple redistribution schemes. We believe the redistribution to be an integral part of the selection problem: even if the efficient host is chosen, there still could exist strong opposition that prevents the efficient outcome from occurring. The planner may want to overcome this opposition by adapting the redistribution scheme to each specific issues (budget constraint of communities, voluntary participation...). To the best of our knowledge, this is the first mechanism which allows to implement both of these objectives. It is simple and at its unique subgame perfect Nash equilibrium, the outcome coincides with truth-telling, is efficient, budget-balanced and immune to any coalitional deviations.

References

BAG, P. K. (1997): "Public Good Provision: Applying Jackson-Moulin Mechanism for Restricted Agent Characteristics," *Journal of Economic Theory*, 73(2), 460–72.

BAUMOL, W., AND W. E. OATES (1988): *The theory of environmental policy.* Cambridge University Press.

EASTERLING, D. (1992): "Fair Rules for Siting a High-Level Nuclear Waste Repository," *Journal of Policy Analysis and Management*, 11, 442–475.

EHLERS, L. (2007): "Choosing Wisely: The Natural Multi-Bidding Mechanism," Mimeo, University of Montreal.

FREY, B. S., F. OBERHOLZER-GEE, AND R. EICHENBERGER (1996): "The Old Lady Visits Your Backyard: A Tale of Morals and Mar," *The Journal of Political Economy*, 104, 1297–1313.

GERRARD, M. (1994): *Whose Backyard, Whose Risk: Fear and Fairness in Toxic and Nuclear Waste Siting.* The MIT Press.

JACKSON, M., AND H. MOULIN (1992): "Implementing a Public Project and Distributing its Cost," *Journal of economic Theory*, 57(1), 125–140.

JEHIEL, P., B. MOLDONAVU, AND E. STACHETTI (1996): "How (Not) to Sell Nuclear Weapons," *American Economic Review*, 86(4), 814–29.

KHUN, R. G., AND K. R. BALLARD (1998): "Canadian innovations in siting hazardous waste management facilities," *Environmental Management*, 22, issue 4, 533–545.

KUNREUTHER, H., AND P. KLEINDORFER (1986): "A sealed-bid auction mechanism for siting noxious facilities," *American Economic Review*, 76, 295–299.

KUNREUTHER, H., J. LINNEROTH-BAYER, AND K. FITZGERALD (1994): "Siting Hazardous Facilities: Lessons from Europe and America.," The Wharton Risk Management and Decision Processes Center, Working Paper no 94-08-22.

LAURENT-LUCCHETTI, J., AND J. LEROUX (2007): ""Why me ?": Siting a Locally Unwanted Public Good," Mimeo, HEC Montréal.

MARCHETTI, N. (2005): "Les conflits de localisation: Le syndrôme NIMBY," *Rapport Bourgogne du CIRANO*, Mai 2005.

MINEHART, D., AND Z. NEEMAN (2002): "Effective Siting of Waste Treatment Facilities," *Journal of Environmental Economic and Management*, 43, 303–324.

MITCHELL, R. C., AND R. T. CARSON (1986): "Property Rights, Protest, and the Siting of Hazardous Waste Facilities," *The American Economic Review*, 76, 285–290.

MOULIN, H. (2007): "Auctioning or assigning an object: some remarkable VCG mechanisms," Mimeo, Rice University.

O'SULLIVAN, A. (1993): "Voluntary Auctions for Noxious Facilities: Incentives to Participate and the Efficiency of Siting Decisions," *Journal of Environmental Economics and Management*, 25, 12–26.

PEREZ-CASTRILLO, D., AND D. WETTSTEIN (2002): "Choosing Wisely: A Multibidding approach," *American Economic Review*, 92, no 5., 1577–1587.

POL, E., A. D. MASSO, A. CASTRECHIN, M. R. BONET, AND T. VIDAL (2006): "Psychological parameters to understand and manage the NIMBY effect," *Revue européenne de psychologie appliquée*, 56, 43–51.

SAKAI, T. (2006): "Fair waste pricing: An axiomatic analysis to the NIMBY problem," Mimeo, Yokohama National University.

SULLIVAN, A. M. (1990): "Victim Compensation Revisited: Effiency versus Equity in the Siting of Noxious Facilities," *Journal of Public Economics*, 41, 211–225.

——— (1992): "Siting Noxious Facilities: A Siting Lottery with Victim Compensation," *Journal of Urban Economics*, 31, 360–374.

A The case of a locally desirable project

A project is to be sited in a community. Let $N = \{1, ..., n\}$ be the set of communities. Each community $i = 1, ...n$ obtains a benefit, b_i, if the project is carried out and a surplus, s_i, if it is the host of the project. We consider that the cost of construction of the project is subtracted to the surplus of all communities (both are specific to the community i) . Let $b = (b_i)_{i\epsilon N}$ be the profile of benefits and $s = (s_i)_{i\epsilon N}$ be the profile of surpluses. The total payoff of a community i if the project is carried out is given by u_i:

$$u_i = b_i + \mathbb{I}(i = host)s_i + t_i \tag{2}$$

Where t_i is the transfers received by community i and $\mathbb{I}(i = host)$ is the indicator function equal to 1 if i is the host and 0 otherwise. A project is efficient if its host h is such that $s_h = max(s_i)$. Without loss of generality we rank communities from highest to lowest surpluses: $s_1 \geq s_2 \geq .... \geq s_n$. Thus, a project is efficient if $s_h = s_1 \geq 0$.

Stage 1: Each community i announces the highest surplus that would be shared if the good is sited in an other community that itself: $s^i = max(s^i_j)$ for all $i \neq j$. Define $\underline{s}$ as the $max(s^i)$. The community i which announce $\underline{s}$ will be referred as the community i^* (the "optimist"). If there is more than one "optimist" then any tie-breaking rule could be applied to select one i^*. If $\underline{s} \geq 0$ we proceed to stage 2, otherwise we stop and the project is not carried out.

Stage 2: Given $\underline{s}$ and i^*, each community announces its own surplus: δ_i for all i. Define δ_h as the $max_{i \neq i^*}(\delta_i)$. The community which announce δ_h will be referred as the host (h).

Then the following transfers are implemented:

$$\begin{cases} t_{i^*} = \alpha_{i^*}(\theta)\delta_h \\ t_i = \alpha_i(\theta)\underline{s} \\ t_h = -\underline{s} + \alpha_h(\theta)\underline{s} + |\underline{s} - \delta_h| \end{cases}$$

Thus, the payoff of each community is:

$$\begin{cases} u_{i^*} = b_{i^*} + \alpha_{i^*}(\theta)\delta_h \\ u_i = b_i + \alpha_i(\theta)\underline{s} \\ u_h = b_h + \alpha_h(\theta)\underline{s} + (s_h - \underline{s}) - |\underline{s} - \delta_h| \end{cases}$$

The theorems below follows directly from Theorems 1 and 2:

Theorem 3. *Let $n \geq 3$, the unique subgame perfect Nash equilibrium of the mechanism coincides with the truthful revelation outcome, $\delta_h = \underline{s} = s_1$, whenever it is efficient to carry out the project. Otherwise the project is not carried out. Thus, the outcome is efficient and budget-balanced.*

Theorem 4. *The unique subgame perfect Nash Equilibrium outcome of the mechanism is immune to any coalitional deviations.*

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